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(February 6, 1979)

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1978 LAKESHORE CAPACITY, PROGRESS REPORT

4. MICROBIOLOGY COMPONENT

MICROBIOLOGY REPORT

LABORATORY SERVICES BRANCH

ONTARIO MINISTRY OF THE ENVIRONMENT

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4.1 PURPOSE AND APPROACH

The main objective of the Microbiology Component of the Lakeshore Capacity Study has been: to define and quantify the relationships among recreational activity/development, the microorganisms which could cause disease in the human user and the incidence of the diseases caused by the microorganisms. In order to reach this objective, a variety of goals were formulated and projects were designed to examine specific subjects and areas of interest. From this variety of goals and projects, the work of the Microbiology Component has largely centered on the relationship among the recreational activity (swimming) at beaches and other types of development, the bacteria, (Pseudomonas aeruginosa) and the disease (otitis externa, an infection of the outer auditory canal). The following report documents the field work which was carried out during the 1978-79 period and some of the findings of that work. In addition, some other smaller projects are outlined.

During the 1979-80, most of the effort by the Microbiology Component (Figure 4.1) will be directed toward:

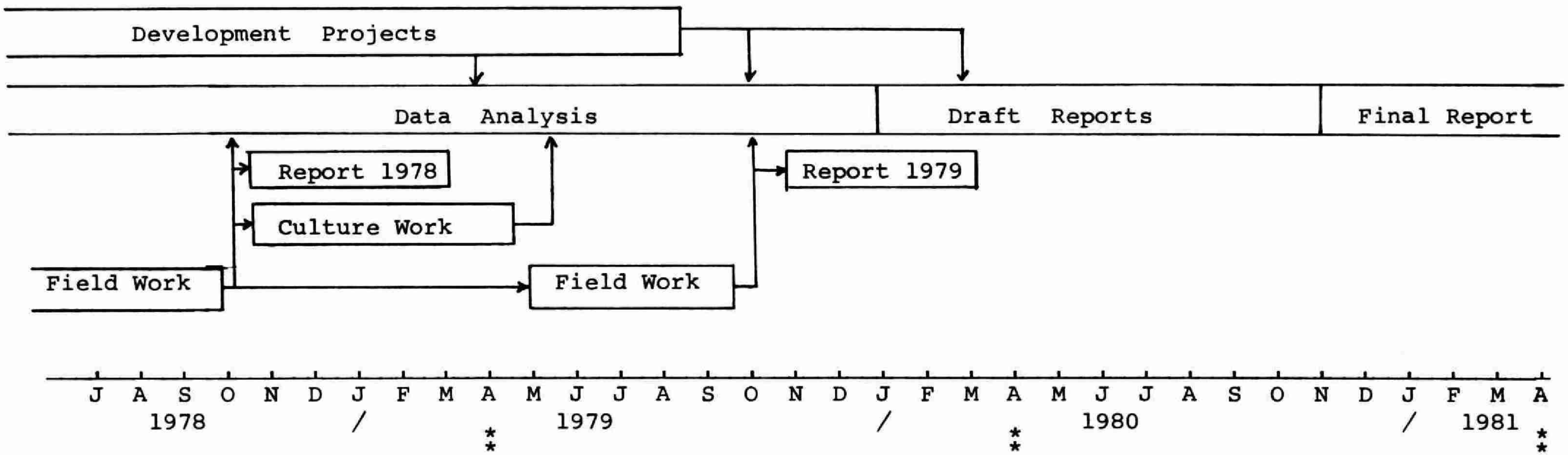
(a) completing and documenting the smaller projects, some of which may propose possible future areas of investigation, some of which need go no further;

(b) analyzing the accumulated volumes of data in order to more clearly visualize trends, relationships and any gaps of knowledge; and

(c) repeating some aspects of our investigation at new and different sites in order to confirm findings or to complement existing data.

The 1980-81 period will be used to finalize all aspects of the work, to prepare documentation and reports and to generally conclude the study.

FIGURE 4.1: Flowchart for proposed work in the Microbiology Component of the Lakeshore Capacity Study from the present time to the end of the Study, March 31, 1981.



4.2 REPORT ON FIELD WORK CONDUCTED IN 1978

This year, as in 1977, the main categories of work conducted by the field staff of the Microbiology Component were the water quality surveys of recreational lakes, the methods development and assessment, and the epidemiology of P. aeruginosa-related ear infections among swimmers.

Due to adverse weather conditions and thick ice cover at lakes of Muskoka-Haliburton, relatively little field work was conducted in the early part of the year. However, water samples were obtained from selected sites and these permitted the determination of bacterial indicators of trophic status and of pathogenic bacteria to continue in the laboratories near Dorset during the winter months. The serotyping and page-typing of P. aeruginosa cultures isolated in 1977 was completed. Considerable time and effort was then devoted to preparatory work for the upcoming epidemiological survey. This work included the design and production of literature and questionnaires the hiring and training of new students and the soliciting the cooperation of physicians, health authorities and municipal officials in the communities where the epidemiological surveys were to be conducted.

With the break-up of ice in May, the field surveys were initiated by the full time staff. Two survey crews conducted water quality surveys at regular intervals at recreational lakes and gathered preliminary water quality information at public beaches well in advance of the onset of swimming activities.

Throughout the spring, summer and fall, water samples were collected from mid-lake sampling stations in each lake and analyzed for chemical and bacterial parameters. Sediment and surface water samples were obtained from shoreline stations that reflected the degree and types of development of the lakeshore. At each station, temperature and dissolved oxygen were recorded. The samples were transported to the Dorset Laboratory and analyzed for some or all of the following bacterial parameters: P. aeruginosa, Yersinia enterocolitica, fecal coliforms, total coliforms, fecal streptococci, Aeromonas hydrophila and heterotrophic bacteria.

Many changes and innovations of the study protocol detail were necessary to accurately determine the role of waterborne P. aeruginosa in ear infections (otitis externa) of swimmers. To ensure success in this regard and in the determination of the relationships between lake usage and incidence of otitis externa in swimmers, it was necessary to greatly increase the sampling frequency and sample numbers and to gather information related to swimming behavior and incidence of disease from a larger population of users of recreational waters.

Throughout the summer and fall the staff conducted diurnal samplings of the water and sediments of the main study site at Gull Lake Beach in Gravenhurst. Surface water surveys of 5 other public beaches in Muskoka-Haliburton were also conducted during the summer. In June, questionnaires and supplies were distributed to local physicians and to hospital emergency wards to obtain ear swab cultures and case histories of ear infection and of swimming activities from patients treated for otitis externa during the summer.

At the time of registration for swimming classes at Gull Lake Beach, nearly 200 children were recruited to participate in the epidemiology study. With the cooperation of municipal officials, the children were assigned to classes according to their age and level of swimming proficiency. These classes were divided into 2 groups of approximately equal numbers of children. The study group was then scheduled to swim on Mondays, Wednesdays and Fridays with a specified number in each class swimming at a specific time on each day of instruction. From this group of children ear swabs were obtained on two occasions, before and after swimming, on each day of swimming instruction. The other group of children together with children and adults of the general public who swam at the beach on alternate days of the week comprised a control group. These swimmers were never swabbed and were not approached again until the final days of the swimming classes in late August.

Prior to the commencement of swimming classes at Gull Lake Beach on each day of instruction of the study group, surface water samples were obtained from 12 sampling stations within the bathing area of the beach at hourly or semi-hourly intervals commencing at 9:00 A.M. On most days the first samples preceded swimming activity. Two sets of sediment samples

were also collected from the bathing area so that one set preceded while the other succeeded the bathing activities. The hourly determinations of air temperature, weather conditions, water temperature at each sampling station, the numbers of swimmers in the bathing area and the numbers of bystanders on the shoreline were recorded. Survey questionnaires and literature were distributed to members of the public who visited the beach. Whenever possible, ear swabs were obtained from swimmers and non-swimmers who were contacted at the beach. During this same period, questionnaires and literature were distributed to swimmers and non-swimmers at five other public beaches and at one private camp.

To facilitate the handling of the increased sample load and to reduce transportation time, a mobile laboratory was moved from Dorset to Gravenhurst to a site near Gull Lake Beach. At this laboratory water samples from the beach were analyzed for P. aeruginosa, fecal and total coliforms and fecal streptococci. Sediment samples were transported to Dorset for analyses. P. aeruginosa cultures obtained from beach samples, from swimmers' ears, from other study sites and from otitis externa patients were preserved in a frozen state for later serological characterization.

At the conclusion of swimming lessons, children in both the study and control groups were thanked for their excellent cooperation and were requested to complete and to return questionnaires concerning their swimming activities and experiences with ear infection during the summer months. Similar mail-in questionnaires were distributed to Muskoka Bay cottagers who participated in the 1977 study. Although the initial rate of return of swimmers' questionnaires was cause for some concern, the final recovery exceeded 80 percent.

At present, work is continuing on the serological characterization of nearly 2,000 P. aeruginosa cultures from various sources and on the analyses of water quality, swimmer density and environmental data.

4.3 1978 MICROBIOLOGY RESULTS

Data analysis is still in progress of most projects. However, some important data is discussed in detail for the major projects. Detailed reports concerning the other projects will be prepared in the near future.

4.3.1 Occurrence of Pathogenic Bacteria in Recreational Lakes - Yersinia enterocolitica

Yersinia enterocolitica is a pathogenic bacterium which has only recently been recognized as a potential problem in North America. Few reports concerning the incidence of Y. enterocolitica in the environment exist and much of the information concerning this organism must be derived from reports of human disease usually associated with the ingestion of contaminated foods. Currently an increasing number of publications report the presence of Y. enterocolitica in numerous species of wildlife, in well waters and in lakes and streams (Harvey, et al, 1976). Other reports have shown that some environmental strains of Y. enterocolitica can pose a serious health hazard to man and animals (Eden et al, 1977; Keet, 1974).

This year the field staff initiated a search for Y. enterocolitica at selected sites on recreational lakes near Dorset. In April, 31 cultures of this organism were isolated from surface water samples. In one sample the Y. enterocolitica density was 24 organisms per 100 ml. Ten of the isolates were serologically identical to strains of Y. enterocolitica that have been associated with human and animal disease. All of these serotyped cultures, however, differed in their biochemical characterizations from those of serotyped clinical strains of known pathogenicity. As such their public health significance in recreational lakes cannot be explained at this time.

Although attempts were made to isolate additional cultures of Y. enterocolitica from recreational lakes throughout the summer and fall, no further cultures were obtained until in December. Efforts are continuing to improve the isolation procedures and to determine the origin of these bacteria in lakewater.

New developments in the procedures for evaluating the pathogenicity of environmental strains may permit health authorities to comment accurately on the public health significance of Y. enterocolitica in recreational lakes. Until then, however, the presence of Y. enterocolitica in recreational lakes should be viewed as indicative of a potential health hazard, particularly now that more lakeshore cottages are being used year-round for recreational activities.

A detailed report on this project is in preparation.

4.3.2 Determination of Aeromonas hydrophila in Recreational Lakes of Muskoka

Aeromonas hydrophila is a heterotrophic bacterium common to most fresh waters. It is of interest to the Microbiology Component because of its association with diseases of fish and with wound infections in man. It may also be of importance as an indicator of organic enrichment of lakes (Bennett, 1969; Jones, 1971).

Using the membrane filtration medium and procedures of Fliermans et al (1977), work was conducted in 1977 and 1978 to determine the levels of Aeromonas hydrophila in recreational lakes of Muskoka. Extensive testing of the medium was conducted in order to determine its selectivity and specificity for this organism from lakes of different trophic status.

Although the medium was found to possess excellent specificity in differentiating A. hydrophila from other organisms, a considerable amount of training and experience was required before technicians became familiar with the subtle differences between the colonies of target (Aeromonas) and non-target bacteria. However, the medium usually was not sufficiently selective for A. hydrophila. Except during a brief period in summer, A. hydrophila could not be recovered without excessive growth of non-target colonies on the medium. In most seasons, therefore, accurate enumeration of A. hydrophila was not possible. A detailed analysis of the data will be required before statements concerning the relationships between levels of A. hydrophila and the trophic levels of recreational lakes will be possible.

4.3.3 Occurrence of Pathogenic Bacteria in Recreational Lakes - *Pseudomonas aeruginosa*

The incidence of *P. aeruginosa* was determined in water and sediment samples obtained at developed and undeveloped shoreline. For this study the definition of developed shoreline was simply lakeshore used for a human purpose - cottages, homes, lodges and public beaches, etc. Undeveloped shoreline was that shore not used by humans in an obvious manner.

The lakes studied were:

Gull	Walker
Jerry (uncottaged)	Three-Mile
Muskoka Bay	Hurricane

The results of samples from the developed shore were compared to those taken along the undeveloped shore. There was no significant difference between the incidence of *P. aeruginosa* in water samples taken from developed shore and that in samples from undeveloped shore (Table 4.1). In order to determine if the densities of *P. aeruginosa* encountered in water samples were greater at either type of shoreline, each sample was weighted by a factor, Density/100 ml + 1 (Table 4.2). No significant difference was noted between the weighted incidence of *P. aeruginosa* in samples from developed and undeveloped shoreline.

In 1977, a significant difference was noted between the weighted incidences of water samples from developed and undeveloped lakeshores. In that year, there was also observed a tendency towards a higher occurrence of *P. aeruginosa* in water samples taken from developed sites as was the case this year.

From the results of sediment analyses (Table 4.3), there was a tendency for a higher incidence of *P. aeruginosa* at developed shoreline areas, but this was not significantly greater than that at undeveloped shorelines. However, a significantly greater incidence of *P. aeruginosa* was observed when the density of *P. aeruginosa* in the samples was accounted for by weighting each sample by a factor, Density/100 ml + 1 (Table 4.4). These results are

Table 4.1: Incidence of *Pseudomonas aeruginosa* (PsA) in shoreline surface water samples of six lakes during summer 1978 * (4 July - 5 September)

Type of Shoreline	Number of PsA Positive Samples	Number of PsA Negative Samples	Total	Frequency % PsA Positive Samples
Developed	17	114	131	12.98
Undeveloped	13	99	112	11.61
Totals	30	213	243	12.35

* The data presented is for the lakes: Gull, Jerry, Walker, Hurricane, Three-Mile W. and Muskoka Bay with the exclusion of Midlake, Inflow, and Outflow data and data concerning the public beach at Gull Lake.

X^2 = 0.10 NSD
P = 0.75

Table 4.2: Weighted incidence of Pseudomonas aeruginosa in surface water of six lakes during summer 1978 * (4 July - 5 September)

Type of Shoreline	Sum of PsA Densities	Weighted No. of PsA Positive Samples	Weighted No. of PsA Negative Samples	Weighted Total	Mean No. of PsA per Sample
Developed	47	64	114	178	(47/131) 0.36
Undeveloped	64	77	99	176	(64/112) 0.57
Totals	111	141	213	354	(111/243) 0.46

* The data presented is for the lakes: Gull, Jerry, Walker, Hurricane, Three-Mile W. and Muskoka Bay with the exclusion of Midlake, Inflows and Outflows and data concerning the public beach at Gull Lake.

X^2 = 2.24 NSD
P = 0.13

Table 4.3: Incidence of Pseudomonas aeruginosa (PsA) in shoreline sediments of six lakes during summer 1978 (4 July - 5 September)

Type of Shoreline	Number of PsA Positive Samples	Number of PsA Negative Samples	Total	Frequency % PsA Positive Samples
Developed	12	96	108	11.1
Undeveloped	3	58	61	4.9
Totals	15	154	169	8.9

X^2 = 1.85 NSD
P = 0.17

Table 4.4: Weighted incidence of Pseudomonas aeruginosa (PsA) in shoreline sediment of six lakes during summer 1978 (4 July - 5 September)

Type of Shoreline	Sum of PsA Densities	Weighted No. of PsA Positive Samples	Weighted No. of PsA Negative Samples	Weighted Total	Mean No. of PsA per Sample
Developed	37.3	49.3	96	145.3	(37.28/108) 0.34
Undeveloped	7.6	10.6	58	68.8	(7.63/61) 0.12
Totals	44.9	59,9	154	213.9	(44.91/169) 0.27

X^2 = 7.89 SD
P = 0.005

in agreement with those of 1977. In both years the incidence of P. aeruginosa in sediment or water samples obtained in the spring and fall were not significantly different for these types of shorelines.

Levels of P. aeruginosa in water samples from developed shoreline sites were similar to those observed in the sediments at this type of lakeshore. At undeveloped shoreline sites, however, the levels of P. aeruginosa in water samples were greater than those observed for the corresponding sediment samples. These observations are similar to those made in the previous year.

In 1977, the results of surface water analysis indicated that there was a tendency for lakes of higher trophic status (Three-Mile, Muskoka Bay) to be more heavily contaminated with P. aeruginosa than lakes of lower trophic state (Hurricane, Gull L.). However, as shown in Table 4.5, this tendency was not obvious in the results of surface water analysis conducted in 1978. In this data P. aeruginosa was least prevalent in the lake of highest trophic status (Three-Mile L.) and was also present in nearly 20 percent of the surface water samples from the undeveloped (Jerry) lake. While the tendency towards higher incidence of P. aeruginosa in lakes of higher trophic status could be seen in the remainder of the data, these two exceptions created new and important questions that can only be answered with more extensive study.

The P. aeruginosa data from surface waters were divided into categories which describe the type of sampling station or types of shoreline development at each station (Table 4.6). As in 1977, the major source of P. aeruginosa in shoreline waters was shown to be public beaches and commercial installations. Similar results were obtained with the shoreline sediments data. These findings strongly supported the view that the effects of human activity along the shoreline on water quality are mainly site specific.

This year P. aeruginosa (Table 4.6) was very frequently isolated from mid-lake stations on all six of the study lakes. While this organism had occasionally been isolated in low numbers from mid-lake stations in 1977, the higher frequency of isolation and the higher densities of the bacterium observed at mid-lake stations of Jerry Lake and the other lakes cannot be

Table 4.5: Frequency of occurrence of Pseudomonas aruginosa (PsA) in surface water samples obtained from shoreline and midlake stations of six lakes in summer 1978

Body of Water	PsA Positive Samples	PsA Negative Samples	Frequency % Positive
Muskoka Bay	13	29	30.9
Walker Lake	13	29	30.9
Gull Lake	29	111	20.7
Jerry Lake	8	34	19.0
Hurricane Lake	5	51	8.9
Three-Mile Lake (west half)	2	25	7.4

Table 4.6: Frequency of isolation of Pseudomonas aeruginosa (PsA) in samples of surface water taken at different types of sampling sites at six lakes in summer 1978

Type of Sampling	PsA Positive Samples	PsA Negative Samples	Frequency % Positive
Inflows	5	34	12.8
Outflows	2	17	10.5
Mid-lake	33	17	66.0
Public beach	628	958	39.6
Commercial	7	27	20.5
Cottaged	10	76	11.6
Undeveloped	13	100	11.5

explained at this time. Whether this phenomenon was observed this year because of the increased sampling frequency or whether it was due to higher mean water temperatures, bacterial growth or rainfall inputs from the watersheds remained to be determined. Cultures of this organism from mid-lake samples are presently being characterized by serological and biochemical tests to determine if these isolates differ from those normally found in shoreline waters.

4.3.4 Epidemiology of Pseudomonas aeruginosa - Related Otitis Externa Among Swimmers at Recreational Lakes

In 1978 the major effort of the Microbiology Component was directed towards the study of ear infections associated with the recreational use of lakewaters. Based upon the preliminary findings of the 1977 epidemiology study conducted at Gull Lake Beach and at Muskoka Bay, an intensive investigation was undertaken in the Muskoka-Haliburton area to determine the etiology of *P. aeruginosa*-related *otitis externa* among swimmers. Since public beaches were the specific sites where *P. aeruginosa* was most prevalent during the summer months, the bathing beach at Gull Lake Park in Gravenhurst was chosen as the primary study site for this project. In addition, several other secondary bathing beaches were included in the study for purposes of comparison. The public beaches examined were:

Gull Lake Beach	(Gravenhurst)
Lions Club Beach	(Port Sydney)
Kinsmen's Beach	(Huntsville)
Hidden Valley Beach	(Huntsville)
Rotary Beach	(Haliburton)
Dwight Beach	(Dwight)

In addition to work at beaches, information gathering surveys were conducted in the major communities of Muskoka and in the Town of Haliburton to determine the swimming behavior of and the incidence of *otitis externa* among a larger segment of the population in the area of concern to the Lakeshore Capacity Study.

The aims of this project (already outlined in the 1977 report) were:

(a) to determine the sources and fate of P. aeruginosa in recreational waters
(b) to determine the influence of bathers and recreational activity on water quality at bathing areas
(c) to determine the role of waterborne P. aeruginosa in the contraction of otitis externa by swimmers
(d) to determine the major environmental factors influencing the incidence of P. aeruginosa in recreational waters
(e) to establish a relationship between shoreline development and usage, and the incidence of the disease.

Although analysis of the project results has not been completed, the following will demonstrate that the aims of the study are very near to achievement.

The 1977 data, showed that the incidence of P. aeruginosa in the shoreline waters and sediments was greatest at public beaches, but the origins of these bacteria had not been determined. In 1978 a significantly greater incidence of P. aeruginosa was observed in water samples taken after the entry of swimmers into the bathing area than in samples from the same sites prior to the entry of swimmers. For days on which swimmers were in the water this difference was highly significant (Table 4.7). On days when swimmers were not observed in the bathing water of beaches (Table 4.8), no significant difference between the incidences of P. aeruginosa obtained in early morning (usually the pre-swim period) and afternoon (usually the post-swim period) was observed. These results provided strong evidence in support of the view that the major source of P. aeruginosa to bathing waters were the swimmers themselves.

The results of fecal coliform determinations in water samples from Gull Lake Beach have been provided in Table 4.9. No significant difference in the incidence of fecal coliforms in morning (pre-swim) and afternoon (post-swim) water samples from the bathing waters could be detected. However, when the mean densities of fecal coliforms in the two types of samples were considered (Table 4.10), the afternoon samples contained a higher level of fecal coliforms than did those obtained in the morning.

Table 4.7: Incidence of Pseudomonas aeruginosa (PsA) in the bathing waters of six beaches in 1978 on diurnal sampling days when swimmers were observed at some time in the water *

Sample Category	Number of PsA Positive Samples	Number of PsA Negative Samples	Total Number of Samples	Frequency % PsA Positive Samples
Morning **	61	313	374	16.3
Afternoon	512	523	1,036	49.5
Totals	573	836	1,409	40.7

* Data concerns public beaches at Mary, Head, Vernon, Peninsula and Gull Lakes and Lake of Bays.

$X^2 = 125.1$ SD
$P = 0.0$

** On 9 of 32 occasions at Gull Lake Beach, swimmers were observed in the water at the time of morning sampling.

Table 4.8: Incidence of Pseudomonas aeruginosa (PsA) in the bathing waters of six beaches in 1978 on diurnal sampling days when swimmers were not observed in the water*

Sample Category	Number of PsA Positive Samples	Number of PsA Negative Samples	Total Number of Samples	Frequency % PsA Positive Samples
Morning	8	193	201	4.0
Afternoon	19	274	293	6.5
Totals	27	467	494	5.5

* Data concerns public beaches at Mary Lake (Port Sydney), Head Lake (Haliburton), Vernon and Peninsula Lakes (Huntsville), Lake of Bays (Dwight) and Gull Lake (Gravenhurst).

$X^2 = 1.45$ NSD
$P = 0.23$

Table 4.9: Frequency of isolation of fecal coliforms (FC) in water samples obtained during diurnal sampling of Gull Lake Beach in summer *

Sampling Category	FC Positive Samples	FC Negative Samples	Total Number of Samples	Frequency % Positive
Morning	80	14	94	85.1
Afternoon	270	36	306	88.2
Totals	350	50	400	87.5

* Summer sampling period = June 29 to September 3 inclusive.

X^2 = 0.64 NSD
P = 0.42

Table 4.10: Cumulative densities and arithmetic mean densities of fecal coliforms (FC) isolated from water samples obtained from diurnal samples from Gull Lake Beach in summer 1978 *

Sample Category	Cumulative Densities of FC in each Sample Category	Total Number of Sample in each Category	Arithmetic Mean Density per Sample
Morning	588	94	6.3
Afternoon	4,899	306	16.0
Totals	5,487	400	13.7

* Densities expressed as number of FC per 100 ml of sample.

These results suggested that an input of fecal material by swimmers may be the manner in which P. aeruginosa was introduced to the bathing waters. From these results, the fecal coliform parameter was less sensitive than P. aeruginosa in assessing the water quality of bathing areas and in determining the influence of swimming activity on water quality.

The incidence of P. aeruginosa in afternoon sediment samples was significantly greater than that of the sediment samples obtained in the morning at Gull Lake Beach (Table 4.11). The relatively lower incidence of P. aeruginosa in the morning samples indicated that sediments did not harbour a significant reservoir of these bacteria from one day to the next. Since the sampling procedures introduced a considerable volume of surface water contaminated with P. aeruginosa along with sediment into the collection vessels, it was not difficult to understand the reasons for increased incidence of P. aeruginosa in the afternoon samples. This relationship between incidence of P. aeruginosa in water and sediments could be seen in a comparison of the data illustrated in Figures 4.2 and 4.3. Similar findings were made in the previous year (Figures 4.4, 4.5).

In Figure 4.2, the highest incidence of P. aeruginosa in the bathing waters of Gull Lake Beach occurred in mid-August and then rapidly declined between that time and early September. Similarly the mean densities of P. aeruginosa in the water samples declined from a maximum in mid-August to a minimum in early September (Figure 4.6).

Based on hourly observations of the numbers of swimmers and bystanders at Gull Lake Beach on each sampling day in 1978, Figure 4.7 illustrates the swimmer density and bystander density throughout the summer. Since most bystanders at the beach were members of swimming classes and entered the water shortly after the enumerations were conducted, the graph of total individuals probably best illustrated the bather load to which the bathing waters were exposed.

The bather load increased markedly in mid-June and then increased more gradually to a maximum in mid to late August. The bather load then declined rapidly into September.

Table 4.11: Incidence of *Pseudomonas aeruginosa* (PsA) in sediment samples taken from Gull Lake Beach during 1978

Sampling Interval	Number of PsA Positive Samples	Number of PsA Negative Samples	Total Number of Samples	Frequency % PsA Positive Samples
Morning	15	141	156	9.62
Afternoon	35	136	171	20.47
Totals	50	277	327	15.29

χ^2 = 7.42 SD
P = 0.01

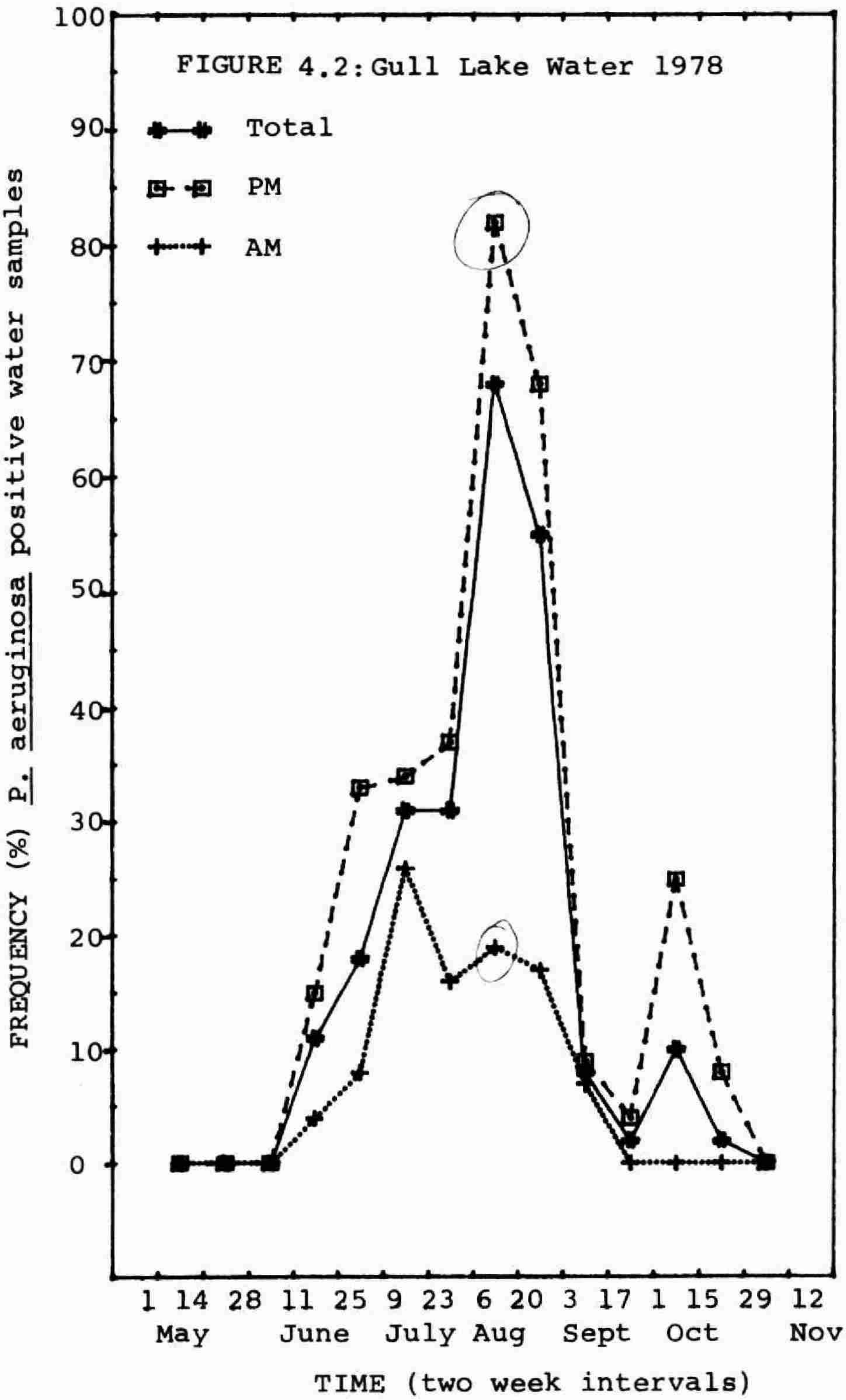


Figure 4.2: Frequency (percent) Pseudomonas aeruginosa positive surface water samples based on the results of diurnal sampling summarized in two-week intervals. Location: Gull Lake Beach 1978.

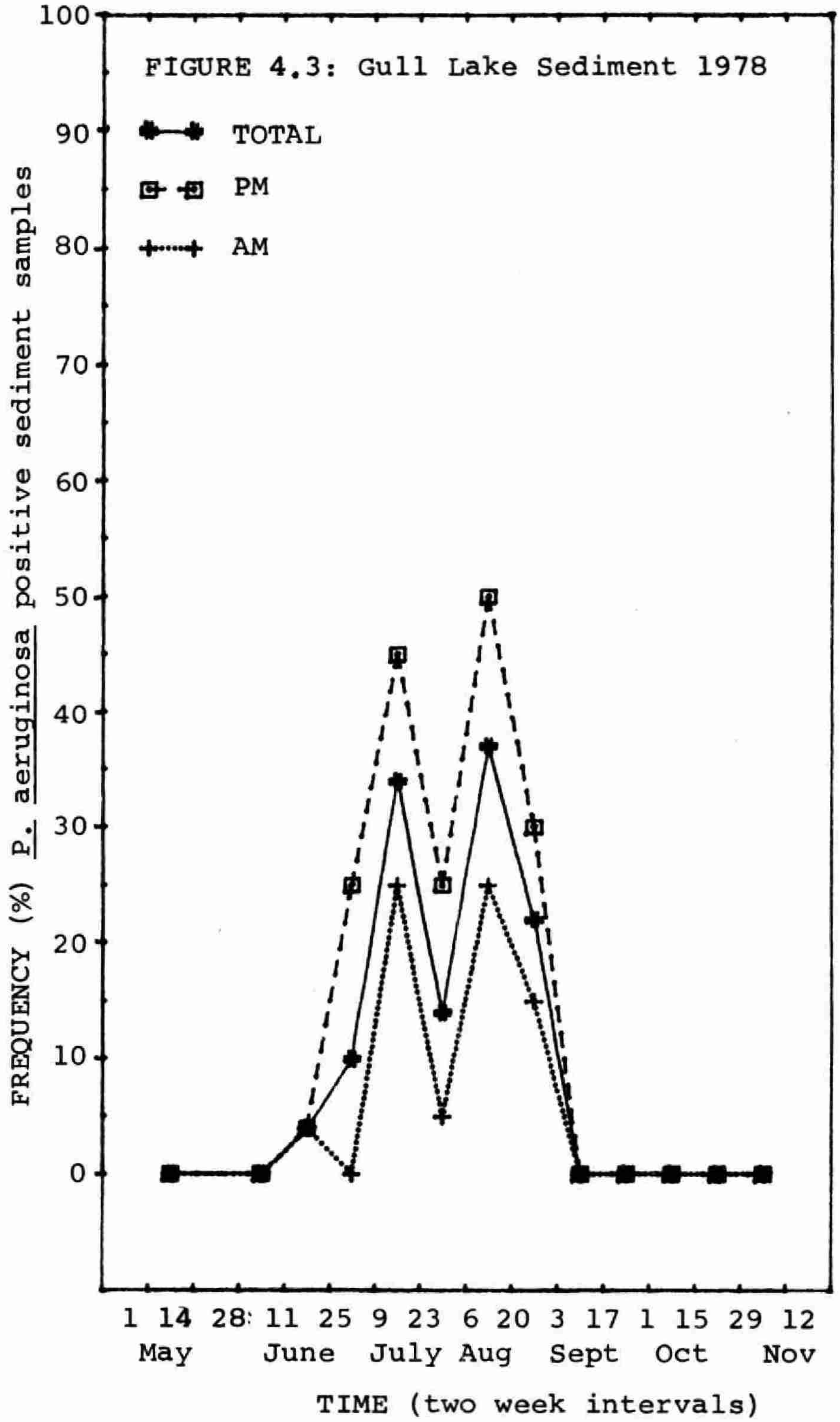


Figure 4.3: Frequency (percent) Pseudomonas aeruginosa positive sediment samples based on the results of diurnal sampling summarized in two-week intervals. Location: Gull Lake Beach 1978.

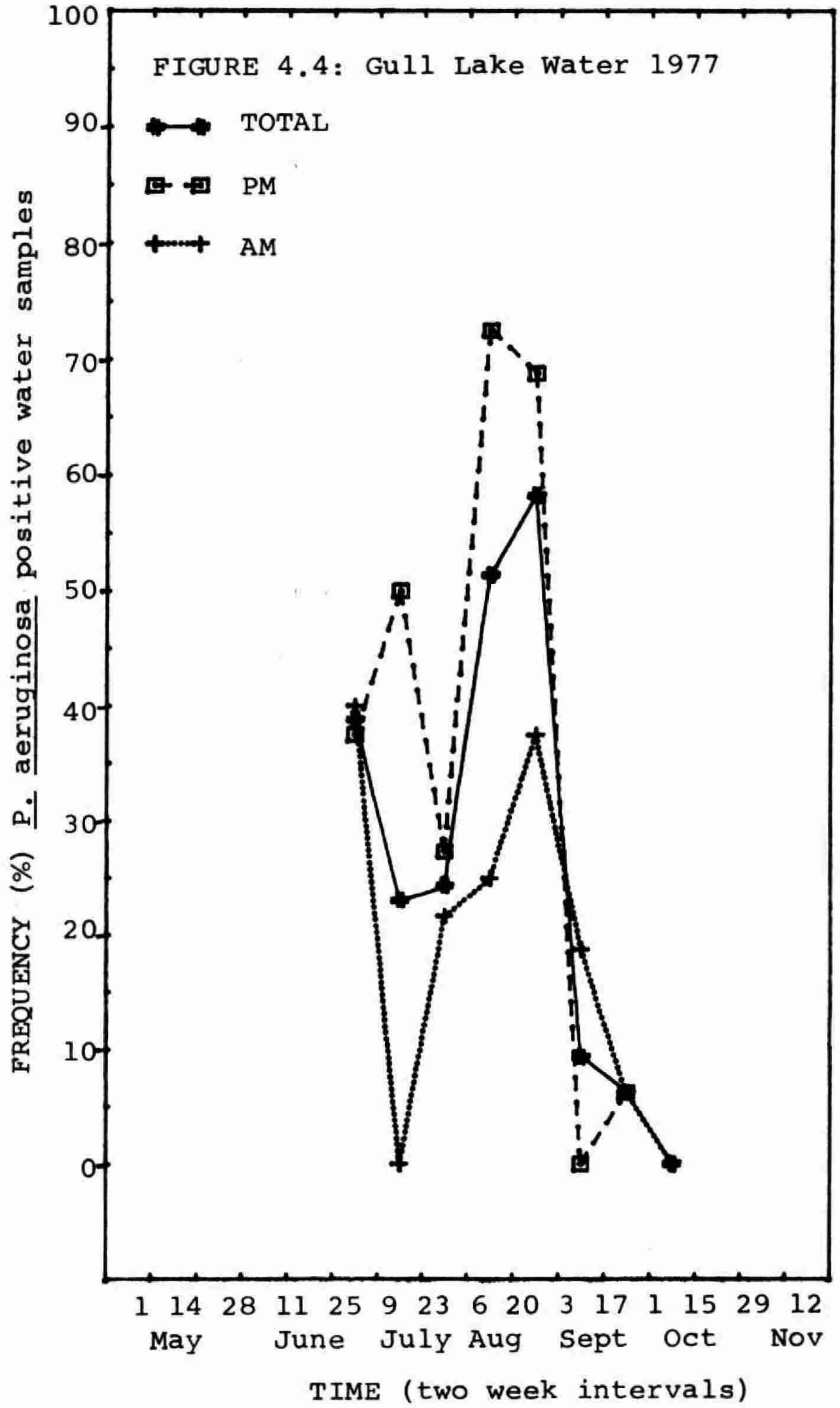


Figure 4.4.: Frequency (percent) Pseudomonas aeruginosa positive surface water samples based on the results of diurnal sampling summarized in two-week intervals. Location: Gull Lake Beach 1977.

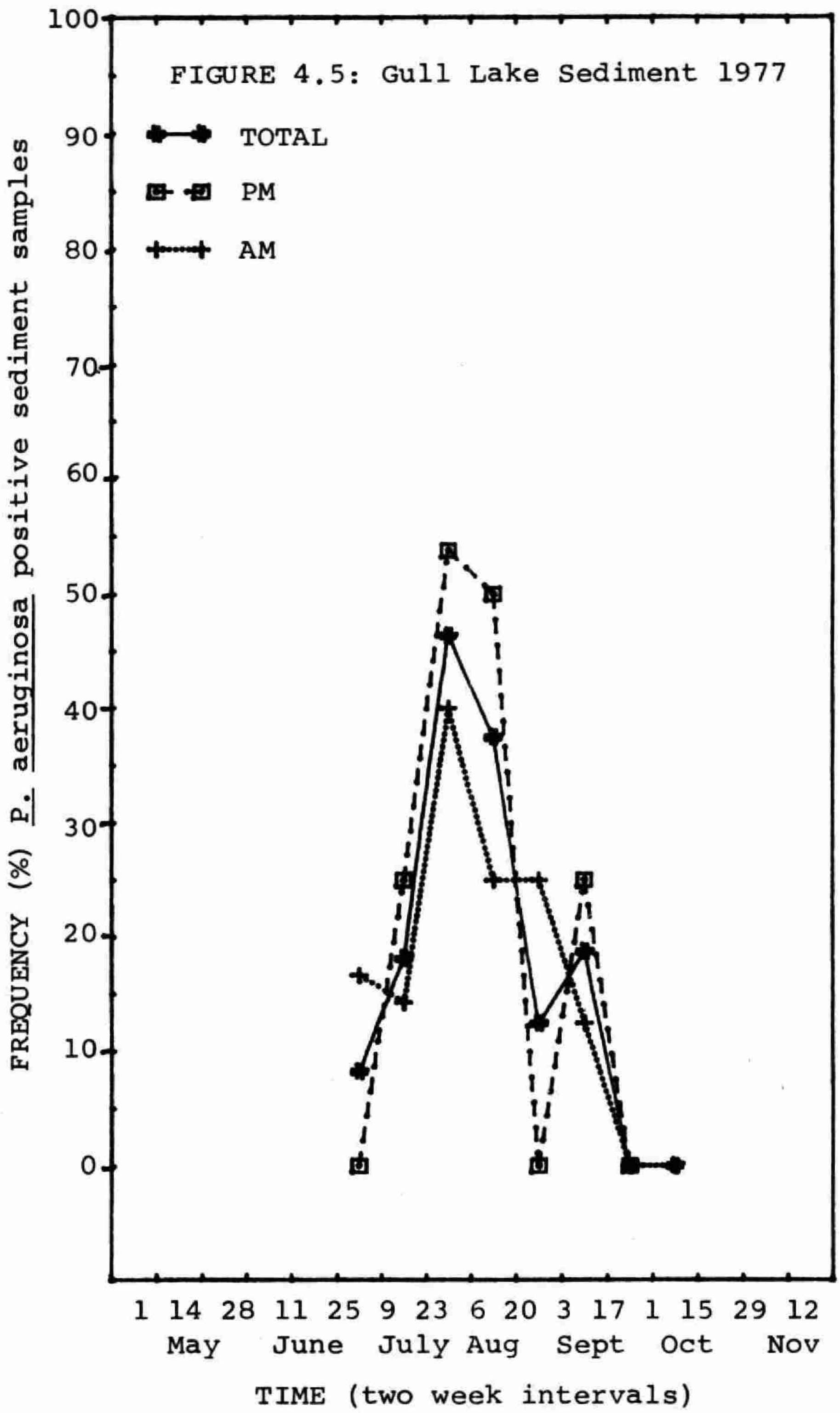


Figure 4.5: Frequency (percent) Pseudomonas aeruginosa positive sediment samples based on the results of diurnal sampling summarized in two-week intervals. Location: Gull Lake Beach 1977.

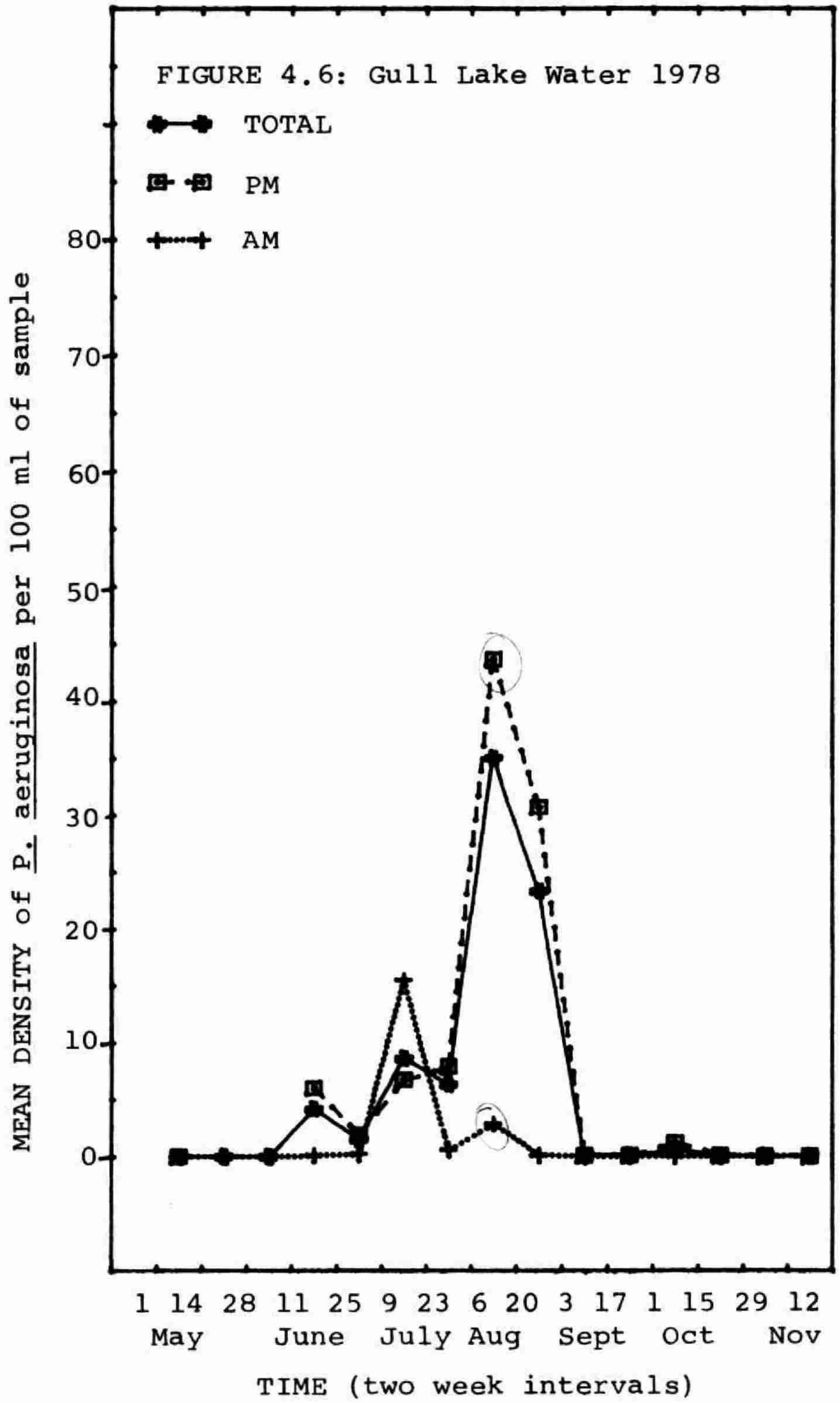


Figure 4.6: Arithmetic mean density of Pseudomonas aeruginosa (number per 100 ml sample) in shoreline water samples based on diurnal sampling summarized in two-week intervals.

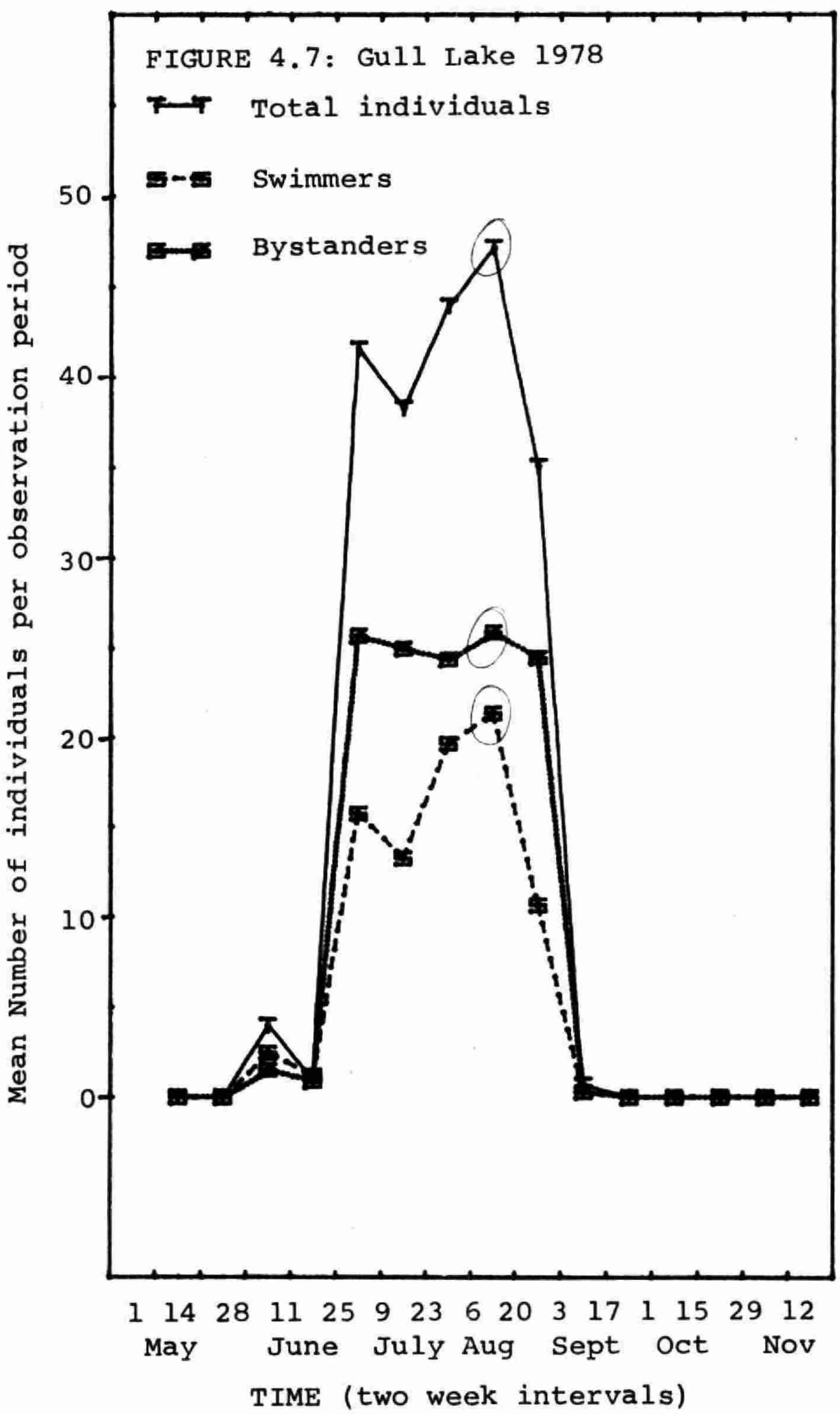


Figure 4.7: Mean number of swimmers (in water), bystanders (on beach), and total individuals per visual observation summarized in two-week intervals. Location: Gull Lake Beach 1978.

Water temperatures increased steadily from mid-May to mid-July (Figure 4.8), increased more gradually until mid-August and then declined until October. During the July-August period, the average water temperature at the beach was in the 22 to 25^{0}C range with occasional maximum temperatures in the 27 to 29^{0}C range.

The relationships among Pseudomonas aeruginosa densities (Figure 4.6), incidence of isolation (Figure 4.2), bather load (Figure 4.7) and water temperatures (Figures 4.8) need to be explored in greater detail before any final conclusions can be made. In this further analysis the diurnal variation of all of these variables will also be included. However, in general, all four of the variables follow a similar season pattern with the maxima occurring in mid to late August. The Pseudomonas aeruginosa densities, however, on upward swing of the graph, increase, then level off for a period of time and then increase again to their final maximum.

The analysis of the ear swabs taken from swimmers before they entered and after they left the water, on each day of swimming instruction, revealed some of the consequences of the intensive use of recreational waters by humans (Table 4.12 and Figure 4.9). In Table 4.12, a significantly greater incidence of P. aeruginosa in the ears of swimmers was detected after the swimmers had bathed in the water than before. This strongly suggested that P. aeruginosa in the water had been transferred to the ears of bathers during swimming activities, and implied that water could be a vector of this potentially pathogenic bacterium.

More evidence for the transmission of P. aeruginosa from water to human ears could be seen in Figure 4.9 in which the incidence of P aeruginosa in the ears of swimmers before and after water contact during the study was illustrated over time. This graph was based upon the results of analysis of ear swabs from only those swimmers whose ears were swabbed on both the pre-swim and post-swim sampling occasions at Gull Lake Beach.

From the plot of this data, it was evident that the incidence of P. aeruginosa in the ear swabs obtained from swimmers after bathing closely parallels the plotted incidence (Figure 4.2) and mean density (Figure 4.3) of P. aeruginosa in water samples from the beach. It was very significant that

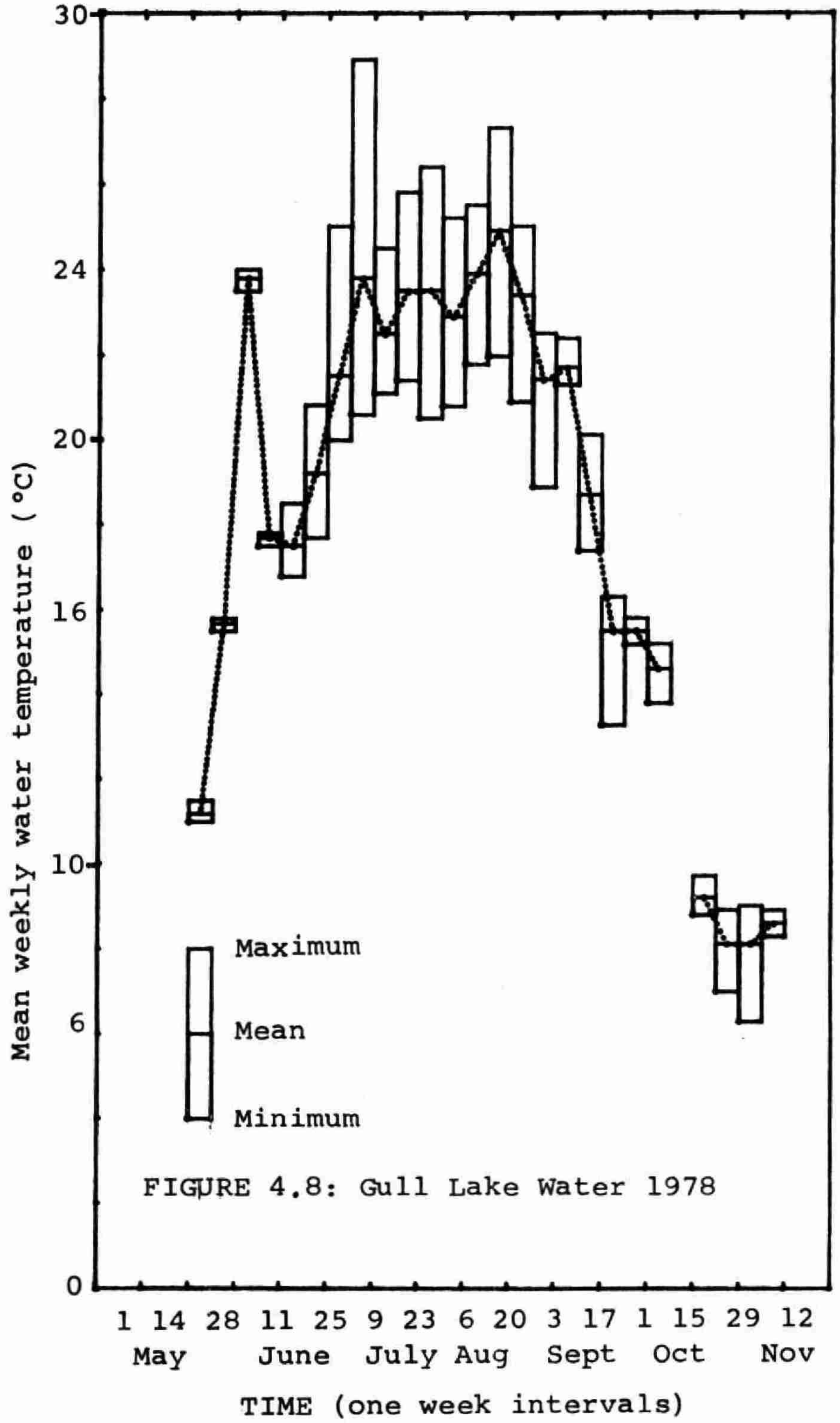
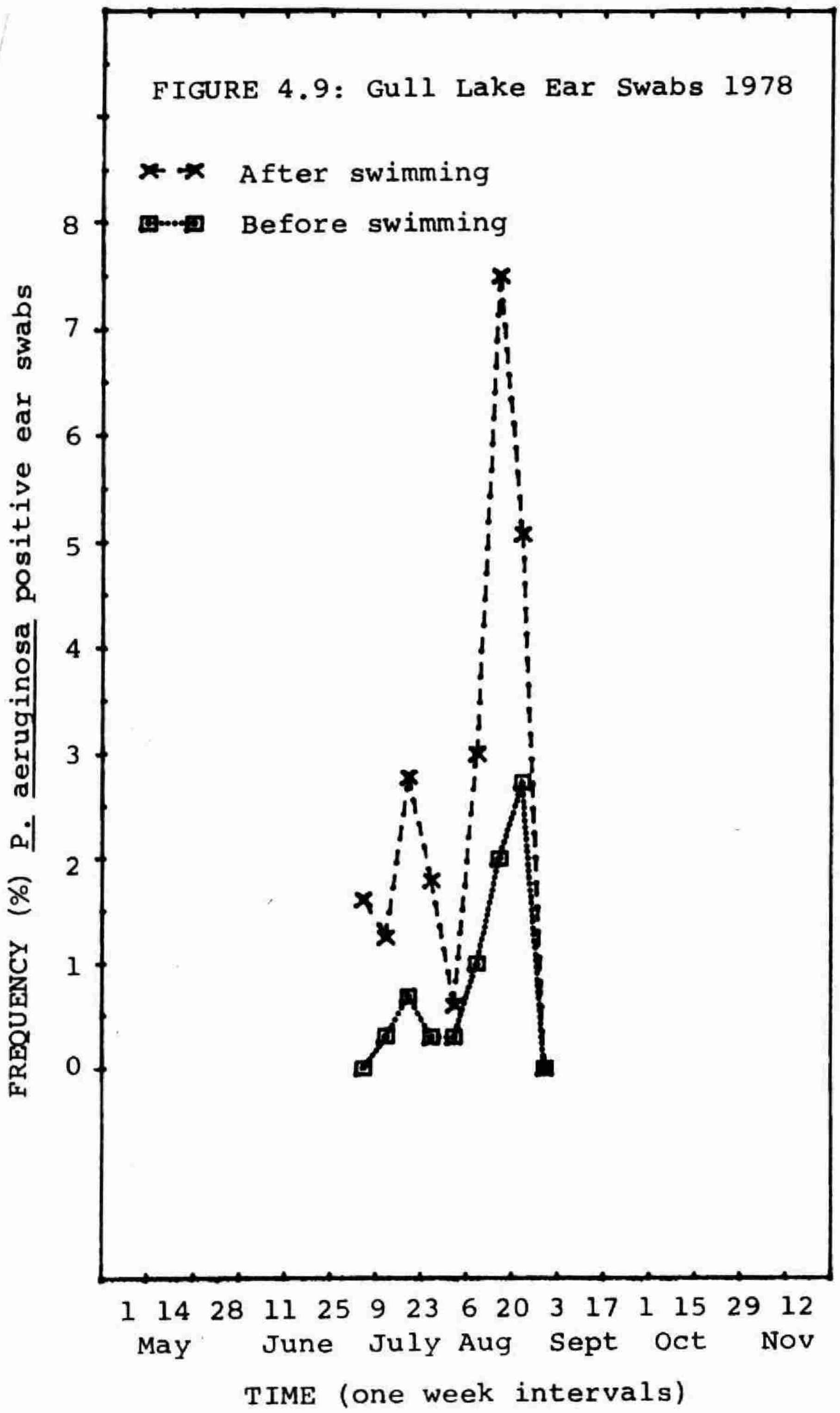


Figure 4.8: Maximum, minimum and mean weekly temperatures observed at Gull Lake Beach during 1978 summarized in weekly intervals.

Figure 4.9: Frequency (percent) Pseudomonas aeruginosa positive ear swabs taken from the swimmer's ears before and after swimming at Gull Lake Beach during 1978 summarized in one-week intervals. Only the data for swimmers who were swabbed on both occasions, before and after, on each sampling day were included in this summary.



highest incidence of P. aeruginosa in swimmers ears occurred during the same period when swimmer density (Figure 4.7) and P. aeruginosa density (Figure 4.6) attained maximum levels at the beach.

In summary, these results strongly suggested a correlation between bather load, bacterial density and incidence of P. aeruginosa.

4.3.5 Epidemiology Questionnaire Responses

Having considered the influence of bathers on the water quality of public beaches and in the transmissions of P. aeruginosa to swimmers' ears, the next part of this report will present data concerning the incidence of otitis externa among swimmers in Muskoka-Haliburton. These data were obtained from the responses of physicians, otitis externa patients, swimmers, non-swimmers and cottagers who participated in one way or another in the epidemiological study.

At Gull Lake Beach, 210 of 233 swimmers and non-swimmers responded to the request for information. Of the respondents, 191 were swimmers while 18 were non-swimmers. Among the swimmers, 21 reported that they suffered from ear infection during the summer months while no cases of ear infection were reported by the non-swimmers. During the analysis of the responses of case histories of ear infection, it became apparent that several victims of ear infection did not obtain medical treatment but rather treated themselves with medication that they possessed from previous encounters with otitis externa. For instance, only 12 of the swimmers obtained treatment from local physicians while the remainder, who were generally well experienced with the symptoms, tended their own affliction. The incidence of otitis externa based on cases diagnosed by physicians, therefore, represented only the minimum level of the disease among swimmers. At Gull Lake Beach these cases made up only 5.5 percent of the swimmer population even though 9.8 percent of the swimmers actually suffered from ear infection.

Additional information concerning the incidence of otitis externa among users of recreational waters was obtained by the analysis of the questionnaires returned by swimmers at different study sites in Muskoka-

Haliburton (Table 4.13). The minimum frequencies of ear infection among the swimmers at each study site was determined by calculating the percentage of ear infections by the number of swimmers surveyed.

At most sites the incidence of ear infection was about 10 percent or greater. Only at those sites where bather density was quite low was the incidence of ear infection very low or negligible. At Muskoka Bay, for instance, swimming activity was generally restricted to cottaged shorelines where the swimmer density was usually much lower than that of public beaches. At the Junior Ranger Camp and at Hidden Valley Beach, the swimmer density and duration of swimming activities was generally much lower than at other sites due to the fact that at these sites the swimmers are temporary residents.

Physicians at their offices or at hospital emergency wards were unable to record all cases encountered or in some cases refused to participate in any manner because of "excessive workload". As a result, many cases of otitis externa went undetected. Nevertheless, 78 cases of otitis externa were reported by area physicians (Table 4.14). For 67 of these cases, ear swabs were obtained from ears that were diagnosed as infected. Analyses of these swabs revealed that P. aeruginosa was associated with 58 percent of the ear infections . When the severity of the methods employed to detect P. aeruginosa in ear swab samples was considered, the true incidence of P. aeruginosa-related infections was likely greater than 58 percent. This value was within the range of frequencies cited for the association of P. aeruginosa with otitis externa (Cassisi et al, 1977) and is greatly in excess of less than one percent cited for P. aeruginosa in the normal ears of humans.

While considerable work is still required to complete the analyses of questionnaire responses and culture sero-typing results, the foregoing report demonstrates that the goal of relating lakeshore development and usage with diseases of public health significance is near achievement.

Table 4.12: Incidence of Pseudomonas aeruginosa (PsA) in ear swab samples taken from swimmers before and after swimming at Gull Lake Beach in 1978 *

Sampling Category	PsA Positive Swabs	PsA Negative Swabs	Total Number of Swabs	Frequency % Positive
Before swimming	18	2,055	2,073	0.87
After swimming	56	2,017	2,073	2.70
Totals	74	4,072	4,146	1.78

X^2 = 19.8 SD
P = 0.0

* Data applies only to those swimmers whose ears were swabbed on both swabbing occasions on each sampling day.

Table 4.13: Minimum frequency (%) of ear infections among swimmers at various study sites in Muskoka-Haliburton

Study Site	Number of Swimmers Surveyed	Number of Surveys Returned	Number of Cases of Ear Infection	Minimum Frequency of Percentage *
Muskoka Bay (cottagers)	240	107	5	2.1
Lion's Club Beach	26	6	4	15.4
Kinsmen's Beach	25	7	5	20.0
Hidden Valley Beach	25	2	0	0.0
Dwight Beach	29	7	6	20.7
Rotary Beach	41	29	15	36.6
Gull Lake Beach	215	192	21	9.8
Mouse Lake Junior Ranger Camp	24	21	0	0.0
Totals	625	371	56	9.0

* $\frac{\text{Number of cases of ear infection}}{\text{Number of swimmers surveyed}} \times 100$

Table 4.14: Number of cases of otitis externa reported by physicians in different communities of Muskoka-Haliburton (May - September 1978)

Community	Number of otitis externa Cases Reported
Haliburton	29
Bracebridge	27
Gravenhurst	4
Huntsville	18
Total	78

4.3.6 Hospitalized Cases of Otitis Externa

As can be seen from the previous discussion, there are many facets to the epidemiology of otitis externa and each provides some additional understanding of the mechanisms required in order for a human to contract the disease. In previous discussions we have dealt with normal healthy individuals with no apparent diseases, with individuals who have contracted the ear infection, but, because of previous experience, treated themselves, and with individuals who have contracted the ear infection and sought medical aid at the doctor's office or emergency ward. There is one more category of individual, namely the one who contracted an ear infection and for a variety of reasons had to be hospitalized for a period of time.

The Ministry of Health data banks were asked to provide information concerning the number of otitis externa hospital discharges for Ontario and the total length of hospital stay. This information covered the period of time from 1973 to 1977 inclusive and was to be subdivided by year, season, age of patient, and location of hospital. Table 4.15 provides a summary of some of this information. There were between 125 and 180 hospitalized otitis externa cases per year in Ontario, and these cases involved between 600 and 1100 days of hospital stay per year.

Figures 4.10 and 4.11 show further breakdown of the information by the age of the patient as well as year and season. Figures 4.12 and 4.13 provide the same information but only for those hospitals located in region 3 which includes Metropolitan Toronto and the counties of Durham, Northumberland, Peterborough, Victoria, Peel, Simcoe, York, Ontario, Muskoka and Haliburton. Figure 4.14 provides the Ontario information adjusted to reflect the proportion of otitis externa hospital discharges as compared to the total number of hospital discharges for any cause. By adjusting in this fashion, the disparity in total number of individuals in each age group might be eliminated.

Table 4.15: Hospitalized otitis externa discharges and days of hospital stay for all hospitals in Ontario by year and season (from Ministry of Health hospital data files)

YEAR	SEASON	DISCHARGES	DAYS
1973	January - March	41	298
	April - June	34	211
	July - September	68	305
	October - December	37	288
	TOTAL	180	1102
1974	January - March	39	247
	April - June	35	217
	July - September	37	194
	October - December	51	278
	TOTAL	162	936
1975	January - March	46	252
	April - June	58	298
	July - September	-	-
	October - December	-	-
	TOTAL	104 +	550 +
1976	January - March	29	184
	April - June	28	195
	July - September	45	214
	October - December	23	137
	TOTAL	125	730
1977	January - March	24	149
	April - June	31	159
	July - September	53	226
	October - December	29	126
	TOTAL	137	660

For this information the following become obvious:

1) the highest proportion of the hospitalized otitis externa cases occurred in the age bracket, 0 to 14 years. This confirms the findings of other workers that otitis externa is a disease of the younger age groupings.

2) there was a seasonal incidence of the disease with the summer months (July - September) providing more cases than other periods of time. This seasonal trend varies with age group and year.

3) there was some year to year variation with 1973 providing more hospitalized cases and more days of hospital stay. This partially confirms verbal statements by some doctors indicating that at the time of the interview, they were experiencing few otitis externa cases but that a "few summers ago" was a particularly bad year for this disease.

4) there were some cases of otitis externa occurring throughout the entire year. Many of these cases may be due to swimming activities associated with swimming pools which are used throughout the year. Some will undoubtedly be due to other causes (Cassisi et al, 1977).

These data do provide information concerning the extremely severe cases of this ear infection. The experience of other workers would indicate that otitis externa of this severity is in a minority since the majority of the cases are treated at the doctor's office, the emergency ward or at home without requiring hospitalization.

Figure 4.10: Distribution of otitis externa hospital discharges for the Province of Ontario by year (1973 - 1977), season (three-month periods) and age of patient.

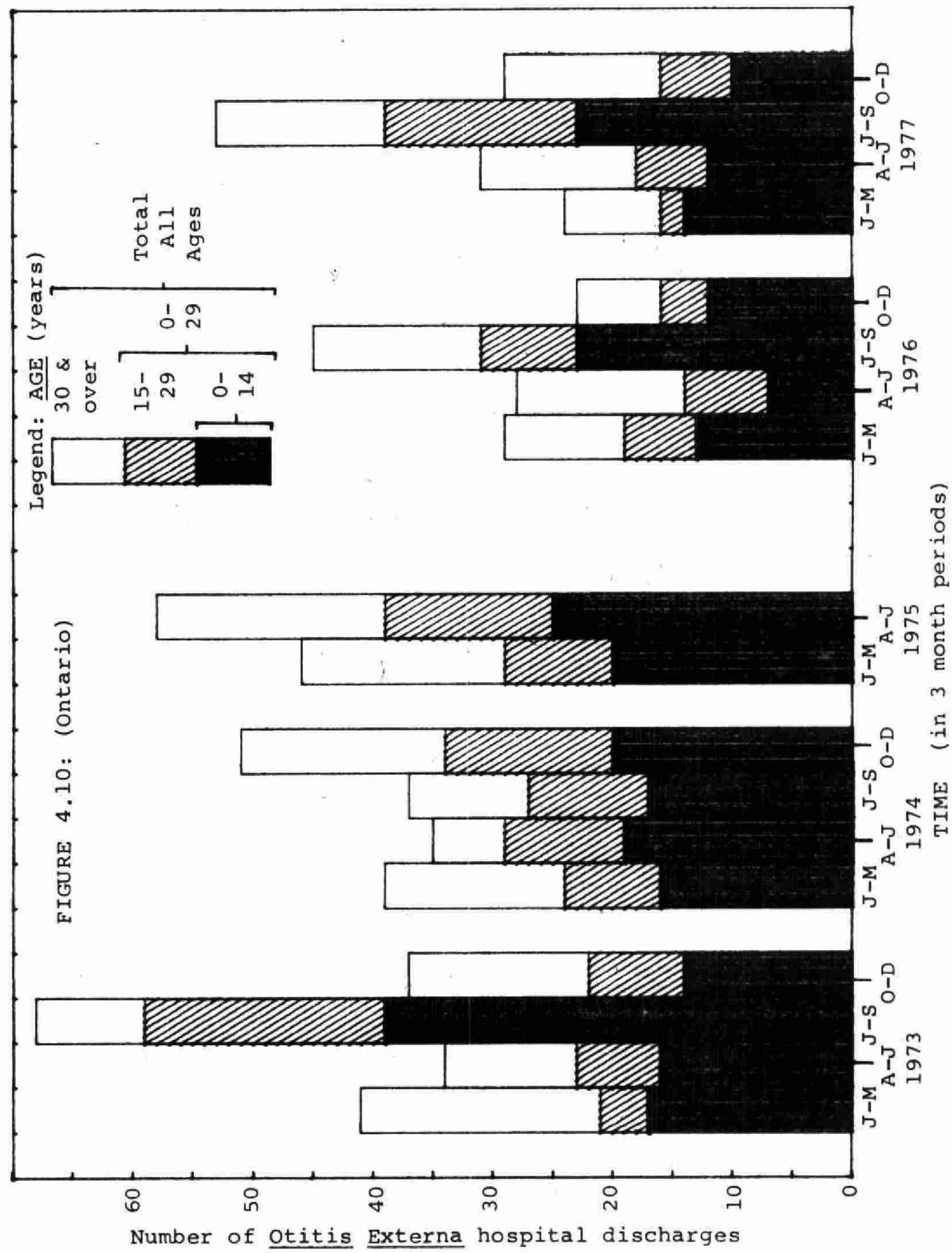


Figure 4.11: Distribution of days of hospital stay due to the disease, <u>otitis externa</u>, for the Province of Ontario by year (1973 - 1977), season (three-month periods) and age of patient.

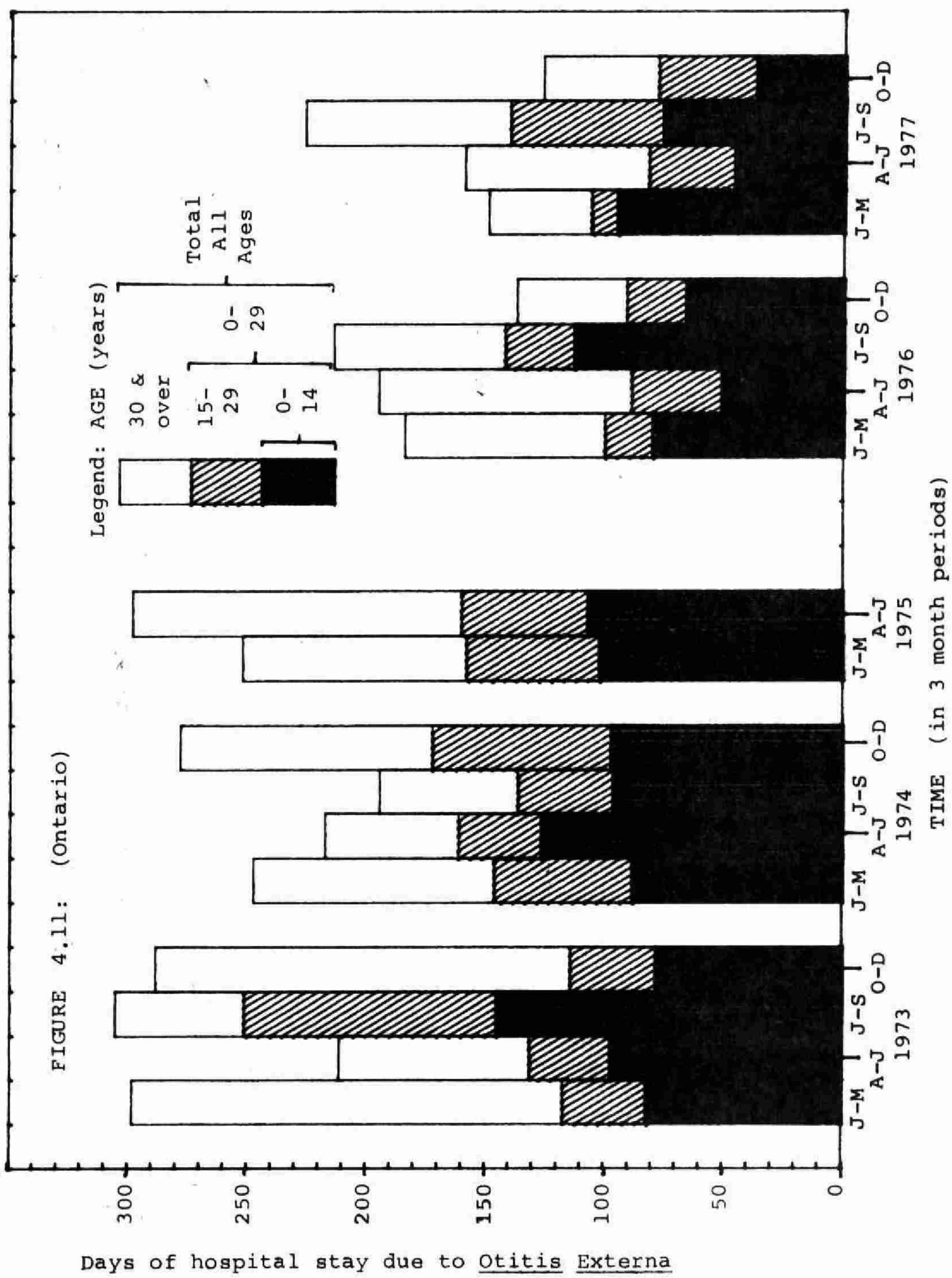


Figure 4.12: Distribution of otitis externa hospital discharges for those hospitals in the Ministry of Health Region 3 by year (1973 - 1977), season (three-month periods) and age of patient.

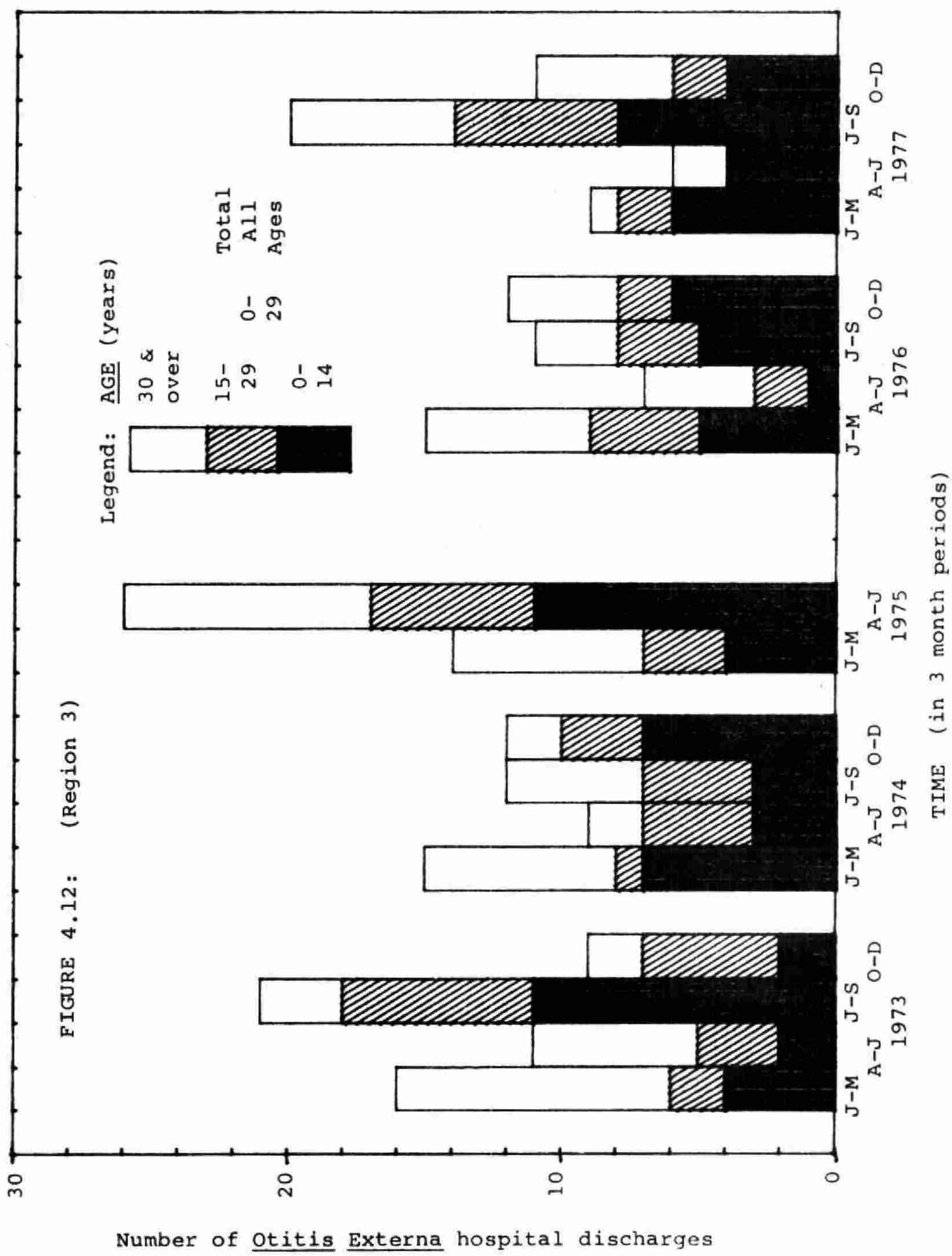


Figure 4.13: Distribution of days of hospital stay due to the disease, <u>otitis externa</u>, for those hospitals in the Ministry of Health Region 3 by year (1973 - 1977), season (three-month periods) and age of patient.

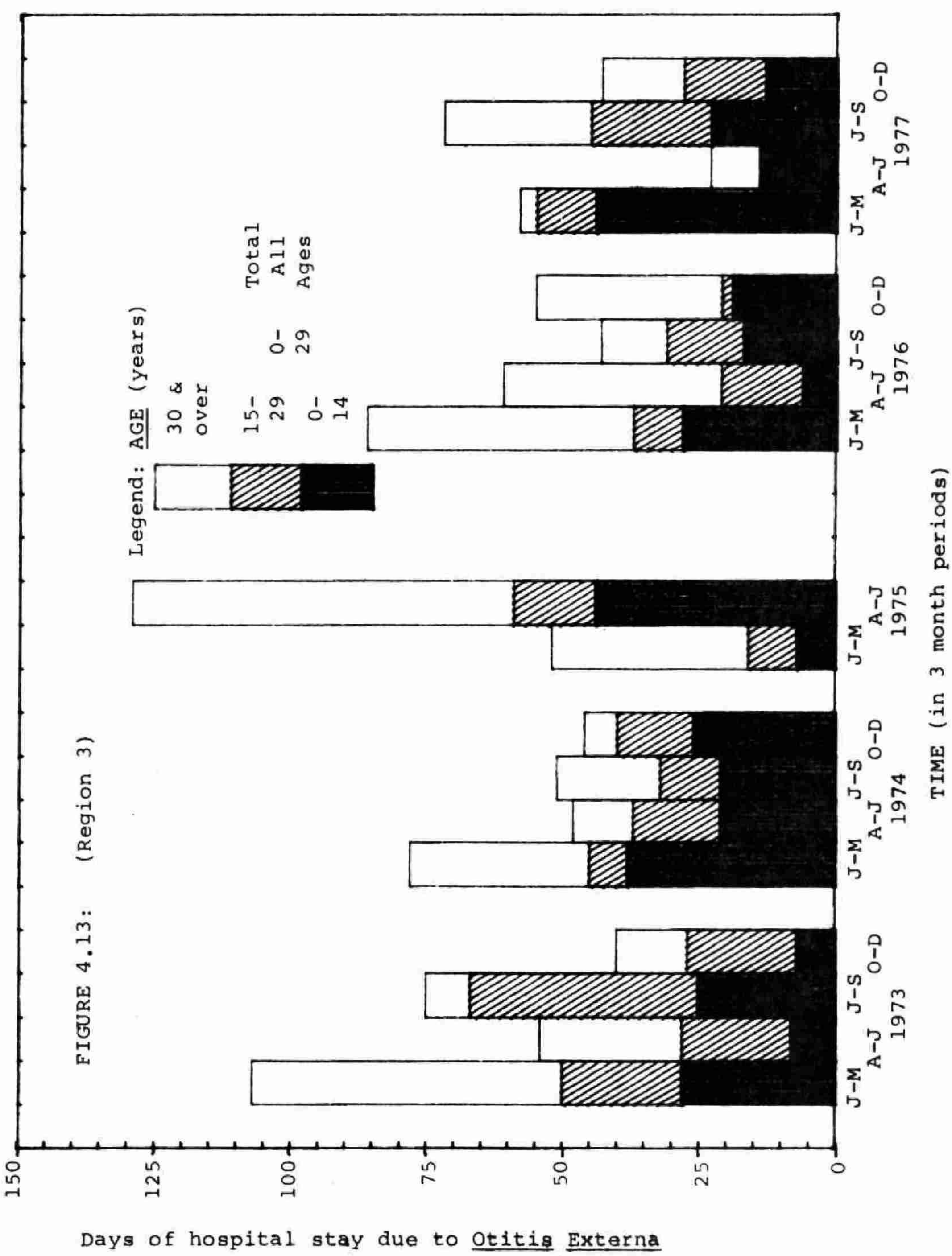


Figure 4.14: Distribution of otitis externa hospital discharges adjusted using the total number of hospital discharges for the Province of Ontario by year (1973 - 1977), season (three-month periods) and age of patient.

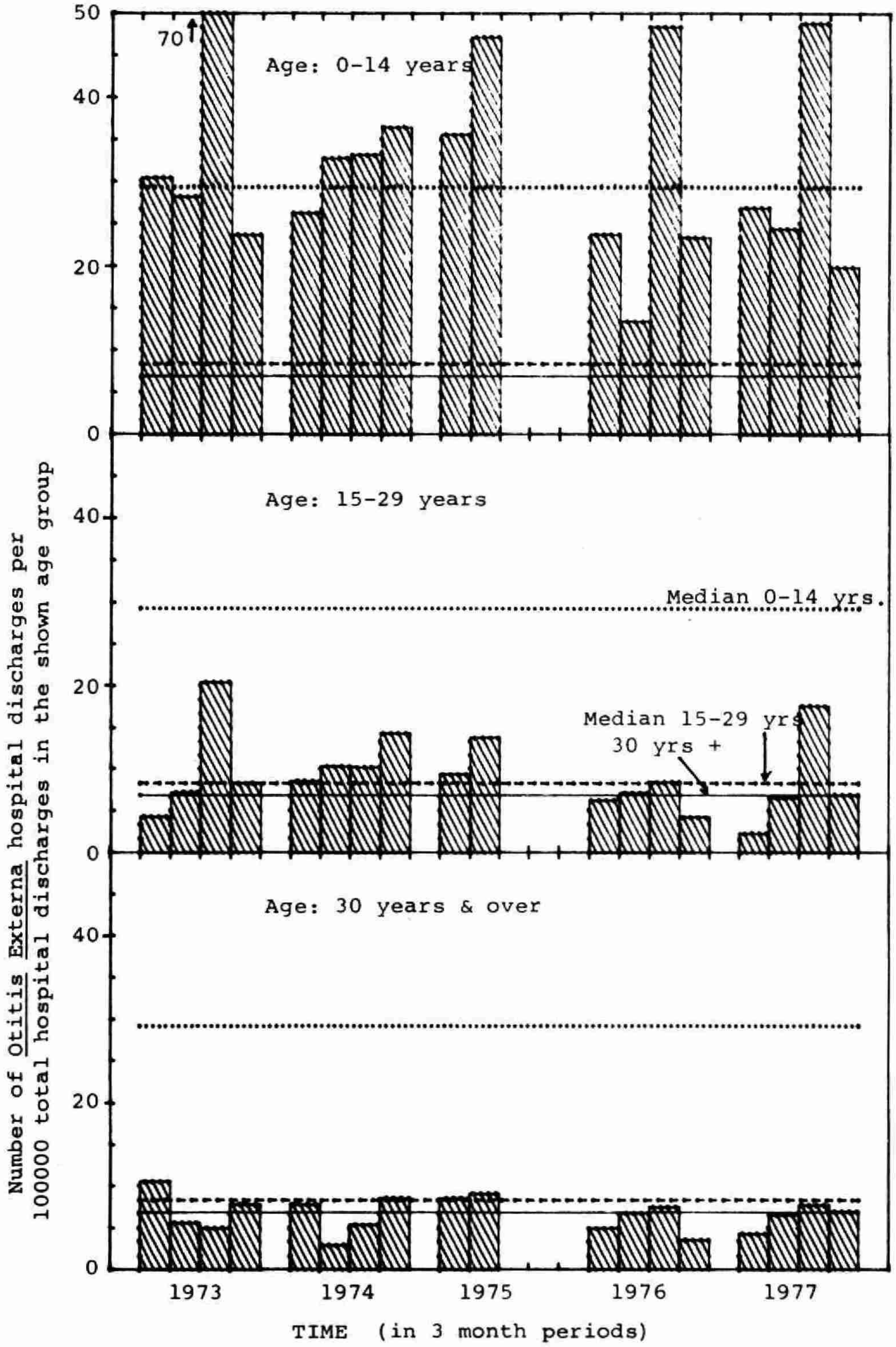


FIGURE 4.14: (Ontario)

4.4 SUMMARY

The trends in occurrence of Pseudomonas aeruginosa in water and sediments, in the numbers of swimmers and in water temperatures followed similar patterns at Gull Lake Beach in 1978 with a maximum in each variable occurring in mid-August. Pseudomonas aeruginosa was more frequently isolated from the water, sediment and ear swabs in the afternoon (post-swimming) than in the morning (pre-swimming).

At Gull Lake Beach, 9.8% of the swimmers surveyed reported having a case of otitis externa. At some other beaches, the incidence could be as high as 36%. While on Muskoka Bay , the incidence was on 2%.

Data concerning hospitalized cases of otitis externa were examined.

Yersinia enterocolitica was found in surface water samples and a potential health hazard may exist.

1979-02-01
K. Lautenschlager
A. Burger
Ministry of the Environment.

4.5. REFERENCES

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